

Feasibility of Using Neural Network Models to Accelerate the Testing of Mechanical Systems

Verification testing is an important aspect of the design process for mechanical mechanisms, and full-scale, full-length life testing is typically used to qualify any new component for use in space. However, as the required life specification is increased, full-length life tests become more costly and lengthen the development time. In addition, this type of testing becomes prohibitive as the mission life exceeds 5 years, primarily because of the high cost and the slow turnaround time for new technology. As a result, accelerated testing techniques are needed to reduce the time required for testing mechanical components.

Current accelerated testing methods typically consist of increasing speeds, loads, or temperatures to simulate a high cycle life in a short period of time. However, two significant drawbacks exist with this technique. The first is that it is often not clear what the accelerated factor is when the operating conditions are modified. Second, if the conditions are changed by a large degree (an order of magnitude or more), the mechanism is forced to operate out of its design regime. Operation in this condition often exceeds material and mechanical system parameters and renders the test meaningless.

At the NASA Lewis Research Center, we theorized that neural network systems may be able to model the operation of a mechanical device. If so, the resulting neural network models could simulate long-term mechanical testing with data from a short-term test. This combination of computer modeling and short-term mechanical testing could then be used to verify the reliability of mechanical systems, thereby eliminating the costs associated with long-term testing. Neural network models could also enable designers to predict the performance of mechanisms at the conceptual design stage by entering the critical parameters as input and running the model to predict performance.

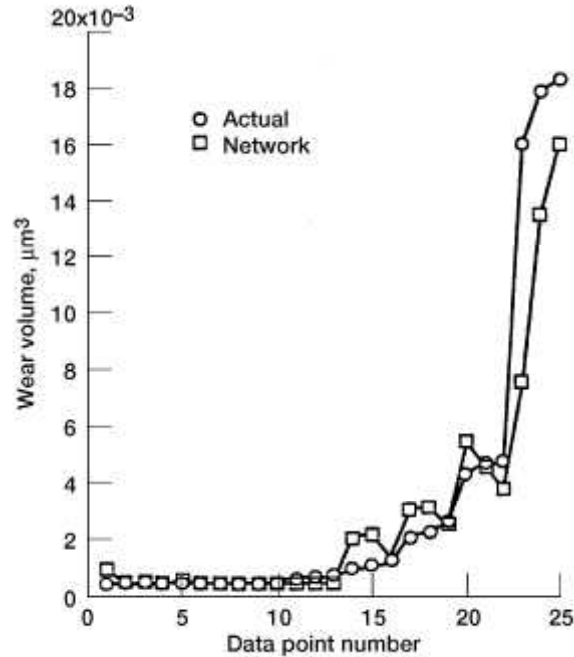
The purpose of this study was to assess the potential of using neural networks to predict the performance and life of mechanical systems. To do this, we generated a neural network system to model wear obtained from three accelerated testing devices:

1. A pin-on-disk tribometer
2. A line-contact rub-shoe tribometer
3. A four-ball tribometer

Critical parameters such as load, speed, oil viscosity, temperature, sliding distance, friction coefficient, wear, and material properties were used to produce models for each tribometer.

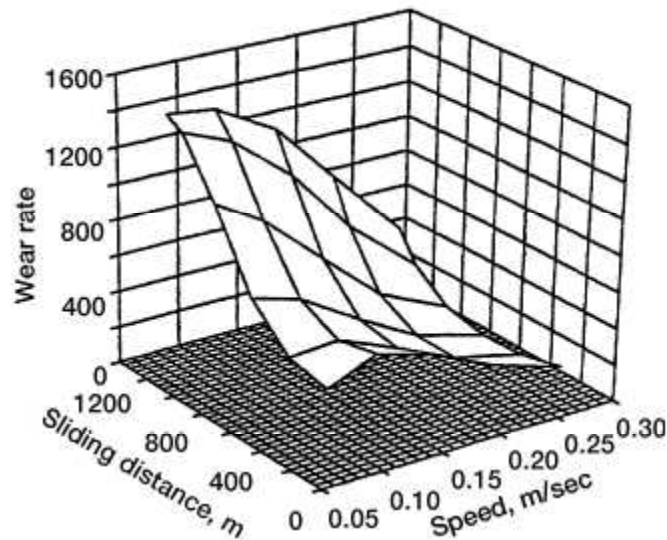
The study showed that neural networks were able to model these simple tribological

systems, illustrating the feasibility of using neural networks to perform accelerated life testing on more complicated mechanical systems (e.g., bearings). The following graph compares actual wear data generated on a rub-shoe tribometer with data that were generated from a neural network. As the graph illustrates, the correlation is very good.



Comparison of previously unknown rub-shoe wear volumes (actual data) to those of a neural network model approximation.

Neural networks can also be used to predict input variables for conditions that have not been run experimentally. The following figure is a neural-network-generated, three-dimensional plot of wear rate (for the pin-on-disk tribometer) as a function of sliding distance and sliding speed. This figure depicts wear rate values that would be obtained for different distances and speeds.



Three-dimensional plots generated from a neural network model illustrating the relationship between speed, load, and pin-on-disk wear rate.

Lewis contact: Robert L. Fusaro, (216) 433-6080, Robert.L.Fusaro@grc.nasa.gov

Author: Robert L. Fusaro

Headquarters program office: OSMA

Programs/Projects: Safety & Mission Assurance